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TRENDS IN MEDICAL AVIATION *

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IN attending the meetings of the Council on Medical Education I have often been impressed by the grasp of our problems, shown by the presidents of our leading universities; it has been their duty to pass on the activities of the medical departments of their institutions. In the same way, during the past eight years, I have been actively engaged in developing naval medical aviation, not as a specialist—a flight surgeon—but as one responsible to the medical department of the Navy for the providing of adequately trained personnel, and the adoption of methods in medical aviation which would be accepted by those concerned with the more vital military problems of training combat fliers and providing efficient aviation material.

During the World War I served as a member of the medical division of the National Research Council and, in the conferences of that group, I gained the impression that, from a medical standpoint, the fitness of a man to fly was to be determined by either the psychologist or the otolaryngologist. At that time some of our ear specialists thought that the ability of a man to conquer the realm of the air rested in perfect functioning of the internal ear, and emphasized the results obtained from the turning-chair and other tests to determine normal equilibrium. The personality or temperamental studies of the candidates were considered by the psychologists as more important, and I must admit that, today, it does seem as if the information obtained from the psychological (neuropsychiatric) examination is of predominating importance.

Of course we must not lose sight of the valuable studies that were being made during the war by a group of eminent ophthalmologists in connection with the requirements of stereoscopic vision and eye muscle coördination in the selection of a pilot.

At times, during the past eight years, it has seemed to me that our flight surgeons were inclined to accept eye muscle balance as the outstanding qualification in the pilot candidate. In particular, the question of permissible defect in the way of hyperphoria has come to the fore and, in establishing a standard for waiver, we have had the constant opinion of that leader in American ophthalmology, General Wilmer. At first we would not accept a candidate with more than 0.5 diopter of hyperphoria, but on the advice of Doctor Wilmer we waive this defect when not

exceeding 0.75 diopter. In 2404 examinations at Pensacola, 54 (2.2 per cent) were thus disqualified. A difficulty seems to be that hyperphoria varies, so that an accepted candidate may later on show more than one diopter of this muscle balance defect. In a study of fatal accidents slight degrees of hyperphoria do not seem to have had any bearing.

The specialists at Pensacola have failed to note any superiority in student pilots who just pass the various eye tests with those who have little or no defect. This would tend to show that, so far, we have not erred in dangerous lowering of standards. The English flight surgeons do not stress eye muscle balance, as do the specialists in our Army and Navy.

FLIGHT SURGEON

I had always thought that the title "Flight Surgeon" was of English origin until, some time ago, I heard an amusing story by one of Doctor Wilmer's associates, who was sent over to England during the war to serve with the British forces. Upon arrival in England a survey was conducted as to those reporting practice in the specialties. This officer reported himself as a flight surgeon and great was the mystification of the authorities as to placing him. Finally it was decided that it must apply to a surgeon who could fly, and he was turned over to the aviation branch to demonstrate his piloting ability. Fortunately he had learned to fly when engaged in his medical aviation duties and passed the flying test, and was sent back with the stamp of approval as a flyer. He did not tell us whether he was then put through tests to determine his qualifications as a surgeon.

Investigating the origin of the designation "Flight Surgeon" it would appear that the first official use of the title was in a memorandum to the Chief Signal Officer, United States Army, dated April 12, 1918, in which occurs the following paragraph:

"In the case of section "Care of the Flier" we have gone over every possible designation and come to the conclusion that that is the only one that would give in a brief phrase any idea of what the activities of the section are. The personnel under this section will be charged with the question of the physical and temperamental fitness of all fliers, whether in training or later in actual service at the front. The researches of our own people who have been looking into this question, as well as the experience of our allies, have made it very evident that the flier must be carefully watched to see that he is fit whenever he makes a flight. This question cannot be left to the individual aviator, nor to his immediate superiors. It is a question of psychologic and physiologic fitness which can only be determined by specially

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trained men who constitute the personnel of this section. These are to be designated Flight Surgeons."

During the latter part of 1920, and the first months of 1921, I was so occupied in making arrangements for the training of our medical officers in nonmilitary specialties that I was unable to take steps to provide our service with specialists in medical aviation, but as soon as the Naval Bureau of Aeronautics was provided for by the Congress, I took up with Admiral Moffett and his assistant, Captain Murfin, the matter of training medical officers as flight surgeons. Captain Mustin was one of the outstanding pilots of the Navy and a man of exceptional executive ability. As a practical flier he felt that it was necessary for a flight surgeon to be first a pilot, in order that he might understand the physical and emotional strains experienced by a man in flying; otherwise he could not gain the confidence of combat pilots. For this training, a period of almost a year was required, and although I felt that a period of flight training of about two months would suffice, yet I thought it advisable to yield to the views of the practical aviator. I may state that later on, and just before he had to leave the Bureau of Aeronautics on account of the illness, which resulted fatally, he agreed that a period of about three months would suffice to give the medical officer the necessary experience in handling different types of planes, and to understand the stress and strain to which the man in the air is subjected.

The pioneer group of naval flight surgeons entered the class at Pensacola and followed the same course as outlined for line pilots. Such a course could not but be of help to the flight surgeon, although it is a question as to his ever using his training in navigation, radio, or motor mechanics.

In a splendid spirit of coöperation General Ireland, the Surgeon-General of the Army, invited us to send our men to join the classes of Army medical officers, undergoing instruction at the school of medical aviation at Mineola.

Following this course we required the prospective flight surgeon to serve the probationary period of three months with an active air unit and, if the commanding officer reported the medical officer as having gained the confidence of his pilot associates and secured recognition of the value of his services, then flight surgeon orders would be issued by the Bureau of Navigation. At the present time, when the importance of medical aviation is so well recognized by the line officer, it is hard to appreciate the difficulties met with by the Medical Corps to secure recognition of flight surgeons. It was necessary to overcome the view that any medical officer could care for the pilot and conduct the physical examinations of candidates. We selected our brightest young men for aviation duty, and always with an eye to tact, because it is essential that a flight surgeon be held in the same regard by his pilot associates, as was the old family physician by his patients.

Following the careers of our first specialists in aviation medicine, I have observed that the most

successful ones have been those who had something of the spirit of the old country doctor—always ready to help anyone, at any hour, day or night.

In the *Air Service Medical*, issued by the War Department in 1919, it was thought that, in addition to the flight surgeon, there was needed for the care of the pilot a physical director, whose duties would be similar to those of a gymnasium director; and a nutrition officer to care for the diet of the fliers. You will remember the importance attaching to physical training during the war, and this influence suggested the physical director. As regards the nutritional adviser, I rather suspect a French source, as even today the French flight surgeons attach great importance to efficient alimentary tract functioning in the fitness of the flier.

We recognize the importance of the care of the diet and athletic training, but think the flight surgeon should himself supervise these important aids to flying efficiency, thus combining three specialties in one. In our development of specialists for the medical service of the Navy we have devoted much thought to the problem of combination of specialties on account of our many hospitals and our limited personnel. From the first, we have been combining ophthalmology and otolaryngology; and we have considered the flight surgeons, on account of the special attention they have to give to eye and ear conditions, as giving us a reservoir for such specialists. Today some of our best eye and ear specialists were former flight surgeons.

TESTS TO DETERMINE PHYSICAL EFFICIENCY

In our Army and Navy great value is attached to the Schneider index, as indicating cardiovascular efficiency. This is an index which has a maximum figure of eighteen, and is made up of six factors: (1) Pulse rate reclining. (2) Pulse rate standing. (3) The difference between these rates. (4) Effect of exercise on these rates. (5) Time of return to standing rate, following exercise; and (6) Difference between reclining and standing systolic blood pressure. The fact that this test apparently gives an exact numerical result appeals to our line officers, and many of our leading flight commanders express the utmost confidence in this test, and have directed that the flight surgeons of their commands make such a test of a flier when there has been a question as to his physical condition. This fact, as well as the great experience obtained by American flight surgeons with this test, makes it one of great importance. It does take a great deal of time, however, to complete the test, and we are all familiar with the inadequacies of the numerous cardiac functioning tests, which have been advanced, and praised, and discarded during the past thirty years.

In the British air service they attach great importance to a test in which the candidate, without rebreathing, maintains a column of mercury at 40 millimeters by blowing through a rubber tube. The time this test can be sustained and the effect on the pulse rate, during a succession of

five-second intervals, gives valuable information as to the cardiorespiratory efficiency.

We used this test in our annual physical examinations of about five hundred naval officers on duty in Washington, but found it necessary to reduce the requirement to 20 millimeters for older officers, as many of them began to show rather marked cyanosis before they would give up. The 40 millimeter standard is one for young men between eighteen and thirty years of age.

Another test, much used by the British, is somewhat similar to that noted above—the length of time the candidate can hold his breath. Not only does this give evidence of cardiorespiratory fitness, but it shows grit—the fellow who holds on until he is, figuratively, black in the face, is the man who does not give up easily.

Our naval flight surgeons are now considering the addition of some type of breath-holding test to the other Schneider factors. The great advantage of the Schneider index is its standardization.

The British authorities attach great importance to a good sports record. According to Flack, a man who has been a good football player at his public school must have a good physique and courage, but, less apparent, is the requirement of character. The other boys will refuse to admit to their games one who is not square and a good sportsman. In the experience of the instructors at Pensacola there does not seem to have been a relation between aptitude for flying and an outstanding athletic record at the Naval Academy. One of the line instructors told me, however, that a good golf player had an advantage.

In the first part of this paper reference was made to the stressing of the Barany tests during the World War, but it is now recognized that vision and muscle sense must be considered in equilibrium as well as the internal ear. Blind-folded pilots, or those flying in the dark, do not seem to be able to recognize change of position, so that the present opinion is that vision is more important in equilibrium than the functioning of the semicircular canals, or muscle sense.

Although we use the Barany chair to determine equilibrium, through nystagmus and falling tests, the British do not consider such tests necessary. There are so many disagreeable reactions following the caloric douche test that the flight surgeons hesitate to use it. During his inspection of medical aviation activities in European countries, Commander Davis, Medical Corps United States Navy, the head of the Division of Medical Aviation in the Bureau of Medicine and Surgery, was interested in a "retarded balance" test, used by the French flight surgeons. The test was performed with the candidate standing, eyes closed, and hands behind his back. Three complete turns were made on the vertical axis, the candidate then assuming a sensitized Romberg position (right foot in front of left if turns made to the right, and left foot in front of right with left turns). A normal individual regains equilibrium in ten to fifteen seconds, and if the candidate does not regain his balance in thirty seconds it is cause for rejection.

This test is so simple and brief that it appealed to me. In my talks with our flight surgeons I have always advised them to simplify and shorten the period of examination whenever possible. The British have a balancing rod test, which we have been experimenting with. There is a thin board, about 4 by 12 inches, which has a slender rod, with a rather unstable base, placed near one end. The candidate has to pick up this board from a table, extend the arm, and then replace the board on the table without upsetting the rod. There is an old idea that a drink of whisky "steadies the nerves," but I understand that the experience of the British flight surgeons is that the pilot who has taken a drink or two upsets the little rod and is thereby grounded.

During the war an apparatus known as the Ruggles orientator was devised, and it was thought that this would, in a practical way, test the candidate as to his equilibrium and other qualifications important to the pilot. The orientator reproduced the movements of the plane in the air in a similar but more sudden and upsetting way. The orientator was a sort of a cockpit of a plane swung within three concentric rings provided with controls within the cage, and a set of controls outside for use of the examining instructor. The candidate, strapped in the machine, can be turned upside down, or in any other position, through the operation of motors controlled by the examiner. When the candidate uses opposite controls, he returns to normal (neutral) position. The main objection to the orientator was that it seemed impossible to provide it with a recording apparatus. About a year ago, however, this was accomplished by the physicists at the Naval Experimental Laboratory, and tests with this graph attachment have been conducted at Pensacola. Lieutenant Commander Poppen, Medical Corps United States Navy, the head of our medical aviation department at the Naval Medical School, has been analyzing these graphs, but his study of these first experiments is not promising. The factors which seemed worthy of consideration were: (1) Reaction time to single control. (2) The consistency of this time. (3) Coördination. (4) Performance time for single control; and (5) Ability to perform multiple tasks. There was little difference between successful and unsuccessful candidates. The best criterion would admit only 8 per cent of students who failed to solo, and 19 per cent of those who failed after having soloed, but would admit only 21 per cent of those qualifying and only 33 per cent of experienced pilots. Further study may prove certain elements of the test to be worth while. Originally it was supposed that by having a candidate start with the orientator the time of training could be shortened, but there does not seem to be foundation for this view. The European flight surgeons attach much importance to tests for reaction time, while in America these tests have not occupied an important place.

TEST TO DETERMINE REACTION TIME

It is very evident that one who cannot think and act without undue retardation is unfit to meet

the sudden emergencies which occur in aviation, and my interest in the recording attachments of the Ruggles orientator was aroused because I thought that this graph provision would give us an apparatus superior to the Reid control indicator which marks reaction time.

In the organization of the Bureau of Medicine and Surgery, medical aviation is one of the activities belonging to the planning division, and the head of this division, Captain Carpenter, Medical Corps, United States Navy, tried for two years to get one of these English machines, without success; and this failure made him particularly desirous of developing a rival in the orientator. In the Reid control the candidate is seated in a cockpit similar to that of an airplane, and operates the controls, which, when in neutral, stop the current to the graph attachment, and, when not in neutral, allow the current to pass. The time required to bring the controls in neutral is recorded, as is also overcontrolling. There are also added auditory disturbances, such as blowing a Klaxon horn behind the candidate. The British have great faith in this apparatus in the selection of pilot candidates.

The French have been very enthusiastic about reaction time tests, not only response to auditory, visual and tactile stimuli, but even recording reaction time to changes of position.

In his visit to Europe, our consulting flight surgeon, Doctor Davis, was impressed with the thoroughness of the Italian flight surgeons in conducting reaction time tests, as well as with those determining equilibrium, and it would seem advisable, unless we have a good method in the recording orientator, to investigate, actively, the problem of measuring reaction time.

About a year or so ago we began experimenting with a simple reaction time and coordination determining test, which we got from Doctor Rippon of the Royal Air Force—the dominoes test. After shuffling up the pieces, the candidate is required to match them, end to end in a long line, but placing the doubles at right angles to the continuing line. A stop watch is used to time the completion of the matching, and failure to match all pieces is checked as well as the time consumed. Our flight surgeons at Pensacola now consider that more important, even than reaction time and coordination ability, is the information to be obtained from the test as to temperamental qualities. The neurotic individual shows a rather characteristic jerky and self-conscious reaction, and Doctor Sutton, our neuropsychiatrist at Pensacola, is of the opinion that, with this test, one can obtain help in the recognition of the introvert, extrovert, and neurotic individual.

TESTS TO DETERMINE PSYCHOLOGICAL SUITABILITY

If this test can help us in placing a candidate psychologically, it is a worthwhile one, because this part of the examination is the one which, in our experience, has proven the most difficult. In grading candidates and accepted pilots, from the neuropsychiatric standpoint, there was the great-

est objection to the use of the designations temperamental and psychological aptitude when an unfavorable opinion was recorded. The naval officers who took the examination felt that any such record would militate against their future service, so that now we make use of the designation aeronautical adaptability, which affects solely a man's fitness as a pilot. We do not resent being told we cannot sing or paint a picture, and the same is true of being told that we cannot fly.

Realizing that we had to bring the pilots to a recognition of the value of aviation medicine, I found that the questioning connected with psychoanalysis aroused antagonism on the part of many officers of the highest type, and I have had many conferences with our flight surgeons about the pros and cons of sexual trends.

The senior flight surgeon at our school of medical aviation, Doctor Poppen, now holds that the flight surgeon should place less confidence in the value of analytical Freudian concepts, and give more consideration to the integral psychology of McDougall, as being more applicable to normal personality. Poppen finds application for Adler's inferiority complex and its accompanying defense mechanism, and still uses Jung's word association test, considering, however, only the average time of response as of practical significance.

Last summer I decided to send Doctor Sutton, one of our ablest and most experienced psychiatrists, to Pensacola to work with the regular flight surgeons in the study of the problem of temperament. Already his help has been recognized by his associates, and his recommendations as to the methods of determining psychological reactions give great promise. One part of his examination is that designated "self-estimate." In this the candidate is questioned as to his self-reliance, sense of humor, irritability, vanity, courage, egotism, and many other characteristics. Lengthened reaction time in replying to these questions is noted by the examiner, and this part of the examination seems to give a more accurate estimate than any other part of the psychological questionnaire.

There are two very important questions to ask the candidate for aviation training, and these are: (1) Whether he would like to fly for the pleasure or sense of accomplishment it would give him (air-minded), rather than from the standpoint of the advantage of increase of pay; and (2) whether there is a marked objection to his flying on the part of his family. A weeping or nagging wife at breakfast may explain a retardation of reaction time when an emergency arises and a crash results a few hours later. From a research standpoint it would be instructive to have a large number of people examined and allow all to start training regardless of physical defects; but I am afraid such an experiment would not meet approval. In England there is an opportunity to study the relation of crashes to physical or psychological defects in the pilots, provision being made to have the pilot (provided he is not killed) sent to the central laboratory of medical aviation for a thorough examination by experts, but

Doctor Davis did not obtain their statistics as to this relation.

The medical aviation service of the Navy did not begin to function until the latter part of 1922, so that those officers who had taken up flying in the four years preceding were not examined physically, other than from the standpoint of an ordinary physical examination. A few months ago I asked Flight Surgeons Poppen and Davies to go over the records of 604 aviators, who were still flying in 1923, but who had been trained prior to the giving of the special type of medical examination. Of these qualified pilots 95.3 per cent showed no defects when examined in 1923 by flight surgeons, 2.8 per cent had recorded minor defects which were waived by the Bureau of Medicine and Surgery, but on the advice of the consulting flight surgeon. (Defects were never waived against the judgment of the consulting flight surgeon.) From the above it will be seen that only 1.9 per cent of these 604 pilots had defects which would disqualify, and it is reasonable to assume that some of these might have developed defects in the years subsequent to their becoming pilots. Unfortunately it was impossible to get information as to the physical qualifications of those who failed to become pilots, or who were subsequently killed in crashes, but the statistics above do show that the man who qualifies in military aviation seems to be the type of man who can pass the flight surgeon examination. With this in view I think we should hesitate to lower the physical standards required for the combat pilot, but it is possible that Major Bauer, and his associates in the Department of Commerce, may find it safe to lower the standards for ordinary commercial flying, although I gather from the statements of expert pilots that the training a combat pilot must receive makes for a safer commercial pilot.

TRAINING OF FLIGHT SURGEONS

With the removal of the Army School of Medical Aviation to Texas, it was found necessary to make other provision for training our flight surgeons. In training specialists for the naval medical service, our policy has been to utilize civilian facilities whenever possible; and with this in mind we approached Dean Meeker of the Postgraduate School of the University of Pennsylvania. A conference was held between Flight Surgeon Davis and myself, representing the Navy, and a number of professors, as well as Dean Meeker, representing the University. In view of the possibilities of commercial aviation these gentlemen recognized the probable need of instituting a course in medical aviation, but the many specialties involved in such a roster and the difficulties of evaluating their respective importance, made them feel that the time was not yet ripe. After outlining our views as to the training of a flight surgeon, the different professors attending the conference were asked to express their opinions. I was much interested in the impressions gained by Professor Weisenberg, who stated that it seemed to him that the important

feature of such a course would be to eliminate members of the class who were temperamentally unfitted to be flight surgeons; the instructors would have to study the student rather than the student study the subject.

Following this conference, we decided to institute a course for flight surgeons at the Naval Medical School, Washington, D. C. Twice a year we have a class of from fifteen to twenty medical officers take a four or five months' refresher course at the school, and during the first two months the entire class is given intensive training in medical aviation physiology, ophthalmology, cardiology, otolaryngology, psychology, and neuropsychiatry. This qualifies any officer who successfully completes the course to conduct the routine examinations for pilots; but for the specialists in medical aviation this is only the starting point. From the class we select three or four officers who show aptitude for this specialty, and for the next two months we have a seminar course, in which the selected group concern themselves with special problems; and in this research training we are fortunate in having the assistance of the Bureau of Standards, St. Elizabeth's Hospital, and the Naval Experimental Station, Bellevue, as well as the opportunity to discuss these problems with the officers of the Bureau of Aeronautics.

Following this seminar course the prospective flight surgeon goes to Pensacola, where he has practical training with groups of aviation personnel for two months; and if he "makes good" he becomes a flight surgeon. The course of probationary training is a six months' one, but it is only after years of experience that one really becomes a flight surgeon. About a year ago we worked out methods for a brief training of medical reserve officers to familiarize them with aviation duties. The course was limited to two weeks, and was only open to ophthalmologists, or others who had had considerable training in eye work; it being recognized that only men who were familiar with eye muscle balance and other eye examinations were prepared to profit by such a short course.

The necessary books and a suggested course of reading were sent the prospective flight surgeon in advance, so that when he arrived at Great Lakes, Hampton Roads, Pensacola, or San Diego, he was acquainted with the necessary groundwork of aviation physiology, psychology, neuropsychiatry, and cardiology.

There is a great field for the flight surgeon in connection with the problems of health extension. (The studies of the actuaries rather throw doubt on the extension of life beyond the Biblical period.) The naval flight surgeon lives with the pilots of his unit, almost on terms of family intimacy. He knows what the pilot eats, and whether he drinks too much coffee or tea; whether the amount of sleep is sufficient, and is familiar with the pilot's exercise habits. In life extension (or "positive" health recommendations) we stress diet, exercise, and mental hygiene, but, frankly, we have very little positive knowledge. **The in-**

dividual constitution varies so greatly that what is good for one may be bad for another.

Almost the only constant health rule that we find in the lives of octogenarians and centenarians is moderation. The flight surgeon is in a position to evaluate health measures and, eventually, to make reliable recommendations.

The outstanding need in medical aviation is international joint action in research, and evaluation of the various tests in use by the different countries. Many of our flight surgeons have regretted the difficulties attending coöperation between the flight surgeons of our Army and Navy; there should be some provision for exchange of flight surgeons so that constructive criticism would be provided.

In our section of the Joint Munitions Board, General Ireland and myself were in perfect agreement that the utmost coöperation must obtain in the medical departments of the two services.

In my opinion, the visit of the consulting flight surgeon of our bureau to the medical aviation centers of Europe has been of inestimable value to naval medical aviation. More progress could probably be made in a few months than in a few years if, instead of working alone, there should be the most intimate association between the flight surgeons of our Army, Navy, and Department of Commerce, and these with a similar activity of other countries of the world.

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THE ENLARGED SPLEEN*

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THE problem of the enlarged spleen frequently presents itself to the physician. In the majority of cases the signs and symptoms are confused and the clinical phenomena are not always closely related to the spleen. Physiologically the spleen is not important, but pathologically it is a menace to the patient, because splenic enlargement of itself increases a function which is not significant, to an overactivity which is not easily controlled through natural agencies.

The lymphoid tissues of the body, of which the spleen is a part, have been named by Aschoff and Landau the reticulo-endothelial system; they comprise a number of tissues with diverse functions not always related to each other. The cells of the sinuses of the spleen are closely related to the Kupffer cells of the capillaries and sinuses of the liver. These structures have in common the ability to develop lymphocytes, which form about 25 per cent of the total white blood cells, and, to a less and varying extent, the mononuclear leukocytes. The lymphocytes are produced in large numbers by the Malpighian tufts and it is probable that the production of lymphocytes is the chief function of these nodes. The lymphocyte, as pointed out by Carrel, has all the properties of growth and nutrition, which he demonstrated in the nurture under glass of fibroblastic tissue. The

phagocytic action of the large mononuclear leukocytes is well marked, and these cells, with the aid of the reticulo-endothelial cells generally, remove from the blood stream and tissues subnormal red blood cells as well as microorganisms and foreign bodies—functions of the spleen which are maintained in the shadowy capillary area between the splenic arteries and veins.

The lymphoid tissues, again, are of interest because they become senescent to a greater or less extent. C. H. Mayo pointed out more than thirty years ago that the lymphatics, after the adolescent period, gradually become less active through the development of fibrous tissues, and that the reason cancer spreads less rapidly in the old than in the young is that the lymphatics of older persons are not sufficiently active to disseminate the disease quickly.

The appendix has a relatively large amount of lymphoid tissue, and undergoes normally the same type of senescence. The gradual disappearance of its lymphoid structure, with the accompanying contraction and obliteration of its lumen, has been wrongly named "appendicitis obliterans." Failure to relieve supposedly related symptoms by appendectomy has given rise to much argument with regard to the validity of chronic appendicitis.

It often happens that tonsils which are very large in youth, by middle age will have shrunk so as to be scarcely noticeable under the pillars of the fauces. The tonsils are lymphoid in structure, and perhaps one of their functions is to permit, early in disease, a few bacteria to enter the blood to stimulate resistance.

The spleen reaches the height of its activity in the adolescent period, and it is during this period that disease of the spleen is most frequently manifest. By the age of forty, the functional capacity of the spleen has become greatly reduced, because of the introduction of fibrous tissue.

The pulp cells of the spleen are efficient phagocytes, and the phagocytic activity of the spleen as well as its strainer function in the removal of bacterial and protozoal and toxic material is aided greatly by the normal disappearance in the spleen of the outer and middle coats of the blood vessels, so that the blood comes in direct contact with the endothelial lining of the splenic capillaries and sinuses. In the dog, the spleen may contain about 20 per cent of the total blood volume, and in times of stress the blood may be forced into the circulation by the nonstriated muscle fibers of the spleen. Undoubtedly this is equally true of man, and perhaps accounts for the left-sided pain in the marathon runner. According to tradition, the ancient Greeks removed the spleen from their runners in preparation for the race.

The control of the action of the spleen apparently depends to a large extent on unidentified internal secretion, since the nerve supply to the capsule from the sympathetic system is scanty.

Our knowledge of the functions of the spleen has been deduced to a considerable extent from the clinical pathology. It has been shown that regardless of the nature of the enlargement of

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